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22nd November 2002

Dear Sir or Madam,

Re: US Patent application Number 09/921,552 filed 08/06/2001
Philip John MARTIN, Tag and Receiver Systems

1. Please find enclosed copies of the following three foreign applications from which this application claims priority, certified with signature and seal.

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United Kingdom 0101580.9 01/22/2001
United Kingdom 0113998.9 06/08/2001

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0101580.9 22 JAN 2001

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

DR PHILIP JOHN MARTIN
6, THE HANUARINGS
HORSMONDEN,
KENT. TN12 8NQ

Patents ADP number *(if you know it)* 7960263001

If the applicant is a corporate body, give the country/state of its incorporation

4. Title of the invention

TAG & RECEIVER SYSTEM

5. Name of your agent *(if you have one)*

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Continuation sheets of this form

Description 9

Claim(s) 2

Abstract 1

Drawing(s) 1 + 1

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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*

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Date 22/1/01

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Tag and Receiver System

This invention is generally concerned with tag and receiver systems, in particular, systems to alert a user to separation form a tagged object. The systems may be employed to reduce the risk of valuable items being left behind, for example, on a train.

From time to time governments have been embarrassed when civil servants have left classified documents on trains or in pubs. Not only is this inconvenient, in some cases a serious risk to national security can result. More generally, it is commonplace for goods to be left behind on trains and other forms of transport and in places of entertainment. Where valuable goods have been lost, frequently these are never retrieved. It is therefore desirable to be able to provide a warning when an object is about to be left behind.

The object to be protected may be provided with a tag transmitting a signal to a receiver carried by, or in close proximity to, the object's owner or bearer. When the tag goes out of range of the receiver it may be assumed that the tagged object has been separated from its owner and is in danger of being forgotten or lost. However, two problems arise with such a simple arrangement. Firstly, since the tag is always transmitting the lifetime of a battery powering the tag can be expected to be relatively short. Secondly, it is desirable to be able to distinguish between accidental impending loss and deliberate abandoning of the object, for example, when the owner wishes to deposit the object in a secure location.

According to the present invention there is therefore provided a system for alerting a user having a tag receiver to separation from a tagged object, the system comprising a tag and a tag receiver, the tag comprising: an activation/deactivation control device; and a transmitter coupled to the control device; the tag being configured to: upon activation, start transmitting; and upon deactivation, transmit a deactivation signal and cease transmitting; the tag receiver comprising: a receiver for receiving transmissions from the tag; a detector, coupled to the receiver, for detecting a reduction in the strength of signal received from the tag and for detecting reception of the deactivation signal from the tag; and an alarm device, coupled to the detector, for providing a user alert when a

reduction in signal strength is detected without a deactivation signal. A corresponding tag and tag receiver.

The tag is configured to transmit a deactivation signal before stopping transmitting, upon deactivation. The receiver is able to detect this deactivation signal and thus distinguish between intentional deactivation of the tag and the reduction in signal strength which occur when the receiver is gradually withdrawn from the tagged object when the object is accidentally left behind. In this way the receiver is able to differentiate between intentional and unintentional cessation of reception of signals from the tag.

In another aspect the invention may detect a rate of reduction of received signal strength and use this to differentiate between the tag being left behind and the tag being deactivated. Thus a gradual reduction in received signal strength indicates that the user of the system is withdrawing slowly from the tagged object whereas a sudden cessation of signal reception indicates that the tag has been deactivated.

Preferably the tag is configured to transmit a deactivation signal upon deactivation as this is more reliable, but a system which detects a sudden cessation of transmission to detect deactivation may be preferred for applications where the tag cost, size or power consumption are overriding factors since by omitting means to transmit a deactivation signal the tag may be smaller, cheaper, and lower in power consumption.

Means to transmit a deactivation signal may be incorporated within the tag transmitter or may form part of the activation/deactivation control device. In a simple embodiment the control device merely comprises a switch; in other embodiments the control device may be operated by a push button and provide a control output on a control line to the transmitter to control the transmitter to transmit the deactivation signal.

The detector in the tag receiver may detect a reduction in received signal strength to below an alert-triggering threshold or a reduction by a predetermined amount or factor. The detected reduction may comprise a partial or a complete signal loss. The alarm device may provide a direct user alert, such as a warning tone, flashing light, or silent

vibration, or an indirect alert, such as a signal to a pager or mobile phone. Preferably, however, a direct alert is provided as this enables the user to take immediate action to prevent loss of the tagged object.

In one embodiment the deactivation signal comprises at least one pulse – that is, the transmitter output signal is pulsed or the signal transmitted from the tag is modulated with at least on pulse. The pulse may be of a predetermined duration; a plurality of pulses may be employed.

Whilst the above described system is adequate in many circumstances, it may be desirable to provide increased security, particularly where the tagged object is especially valuable. The tag effectively provides a beacon which could alert a miscreant to the valuable object's presence. Preferably, therefore, the tag is an rf tag providing an rf output modulated by a baseband signal comprising at least the deactivation signal, and wherein the half power bandwidth of the rf output is at least ten times the half power bandwidth of the baseband signal. Preferably the tag transmitter is a spread spectrum transmitter, such as a direct sequence or frequency hopping spread spectrum transmitter.

Use of a spread spectrum transmitter makes tag transmissions hard to detect unless the spreading code is known. The tag transmitter may approximate the Bluetooth (RTM) standard, which is advantageous as transmissions from the tag may then be hidden by other Bluetooth transmissions. In a simplified spread spectrum system the transmitter may be keyed on and off by a signal, such as a tone, with a narrow mark:space ratio. Such narrow AM pulses provide a broad transmit spectrum.

The control device may comprise an orientation-operated switch such as a mercury tilt switch or a tremble switch. This simplifies tag installation where a push button is undesirable. With this arrangement the user must always leave the tagged object in a predetermined orientation. For example, an umbrella normally lies horizontally but is carried vertically or at an angle. An external push button may also be avoided using a magnetically operated switch such as a reed or Hall effect switch..

These and other aspects of the invention will now be further described, by way of example only, with reference to the accompanying figures in which:

Figures 1a and 1b show, respectively, a tag and a tag receiver;

Figures 2a and 2b show, respectively, a block diagram of a tag and of a spread spectrum transmitter; and

Figure 3 shows a block diagram of a receiver for the tag of Figure 2.

Referring to Figure 1a a tag 100 comprises a mercury tilt switch 102 coupled to a tag transmitter 104 which in turn feeds a tag antenna 106 for transmitting to a tag receiver. The tag may be installed in an object to be protected such as a briefcase or laptop computer. The tilt switch is arranged so that the tag is activated when the tagged object is in a suitable resting orientation, such as horizontal for a briefcase. For a laptop the tilt switch may be installed in the screen so that the tag is active when the laptop is resting horizontally, but not in use (ie. when the screen is folded flat).

Figure 1b shows a tag receiver 200 comprising a receiver antenna 202, a receiver 204 to receive transmissions from tag 100, a detector 206 to detect reception of a deactivation signal from the tag and an alarm 208 to alert a user of the system when the received signal strength of transmissions from the tag fall below a preset threshold without the deactivation signal having been received. Preferably the alarm alerts only the user, and a pager or mobile phone vibrator is suitable.

Figure 2a shows a block diagram of a tag in more detail. A power source 200 comprises a small battery such as a button cell and a tag activation control circuit 202 is permanently powered and thus preferably comprises low power, eg CMOS, circuitry. A push button 204 is coupled to activation control 202 for activating and deactivating the tag, eg. with one or two pushes. Activation control circuit 202 controls a power switch 204, eg. a MOSFET, which switches power to a transmitter 206. The control circuit 202 controls switch 204 to begin and cease transmissions.

A data line 208 from control circuit 202 provides a data input to transmitter 206 which provides a modulated transmit output signal to antenna 210. The data line 208 is used to modulate the transmitter output with the deactivation signal. In other embodiments the transmitter is modulates by switching its power with switch 204.

When push button 204 is used to activate the transmitter control circuit 202 operates to switch on power to transmitter 206 but data line 208 is held at a constant level, eg logic 0 or 1. When button 204 is operated to deactivate the transmitter control circuit 202 first outputs a deactivation signal on line 208 which modulates the transmitter output, and then controls power switch 204 to switch off the transmitter.

Figure 2b shows transmitter 206 in more detail. The transmitter comprises an oscillator 212 which generates an rf carrier which is provided to a first terminal of a mixer 214, the output of which is coupled to transmit antenna 210. A PN code generator 216 generates a spread spectrum spreading code which is combined with data on line in mixer (multiplier) 218. The output of mixer (multiplier) 218 thus comprises a PN spreading code modulated by the data input, and this is fed to a second terminal of mixer 214, which thus generates a DSSS output.

The output of the PN code generator 216 is arranged to move between binary signal levels of +1 and -1 so that when mixed with the output of oscillator 212 a binary phase shift keyed (BPSK) signal is provided to antenna 210. Mixer 214 is preferably a balanced mixer and may be constructed from a dual-gate FET or from a differential amplifier. Other forms of modulation such as differential BPSK and CPSM (continuous phase shift modulation) can also be used.

Oscillator 212 is preferably physically small and has a relatively low current consumption and power output. In general oscillator 212 may operate at any frequency, although the frequency should be high enough to allow modulation of the PN code sequence onto the carrier without excessive spectrum occupancy. In the UK the ISM (Industrial, Scientific and Medical) frequency band of 2.4-2.4835GHz is explicitly designated for spread spectrum transmissions provided these have an EIRP of less than

10mW per 1MHz of spectrum occupancy. In the US additional frequency bands of 903-928MHz and 5.725-5.85GHz are also available for spread spectrum devices.

In a preferred embodiment oscillator 212 operates at about 2.4GHz and provides an output power in the range 0.1dBm to 1dBm. A small, low-power oscillator for these frequencies can be constructed using a ceramic resonator or a stub comprising a resonant length of solid coax. Mixer 214 preferably incorporates a buffer and impedance matching circuitry to optimise its coupling to antenna 210. Since a 1dBm transmitter output is sufficient to provide the necessary range, no amplification is necessary for this application. (Where longer ranges are required, a monolithic microwave integrated circuit (MMIC) can be employed to boost the transmitted output to around 10dBm).

PN code generator 216 generates a pseudonoise spreading code as is know to those skilled in the art for spread spectrum use. Such codes are described in Spread Spectrum Communications Handbook by M.K. Simon, J.K. Omura, R.A. Scholtz and B.K. Levitt, McGraw Hill, 1994 and in Digital Communication with Fibre Optics and Satellite Application by H.B. Killen, Prentice Hall International, Inc., 1988. Reference may also be made to the following, which are also incorporated by reference: CDMA - Principles of Spread Spectrum Communication by A.J. Viterbi, Addison-Wesley, 1995 and Digital Communications by J.G. Proakis, McGraw Hill International, 3/e 1995.

As is known to those skilled in the art, a PN code is a pseudorandom bit sequence with a strong autocorrelation at zero relative shift and a weak autocorrelation value elsewhere. Different PN sequences preferably have a low cross-correlation coefficient for both full and partial overlap. The bits of a PN spreading code are often referred to as chips. With a chip clock of f_c and a spreading sequence of length N_c a PN code has a line spectrum with a line spacing of f_c/N_c and a sinc^2 envelope with nulls at $\pm f_c$.

A PN code may be generated by an n-stage shift register with EXOR (modulo-2 addition) feedback taps at specified positions. A simple PN code is a maximal length sequence or m-sequence, which has a length of $N_c = 2^n - 1$. Some exemplary shift register tap points are as follows:

No of stages (n)	Code length (N_c)	m-sequence tap points
6	63	[6,1] [6,5,2,1] [6,5,3,2]
7	127	[7,1] [7,3] [7,3,2,1] [7,4,3,2] [7,6,4,2] [7,6,3,1] [7,6,5,2] [7,6,5,4,2,1] [7,5,4,3,2,1]
8	255	[8,4,3,2] [8,6,5,3] [8,6,5,2] [8,5,3,1] [8,6,5,1] [8,7,6,1] [8,7,6,5,2,1] [8,6,4,3,2,1]
10	1023	[10,3] [10,8,3,2] [10,4,3,1] [10,8,5,1] [10,8,5,4] [10,9,4,1] [10,8,4,3] [10,5,3,2] [10,5,2,1] [10,9,4,2]

The taps can be reversed, that is a tap at a position I is substituted by a tap at a position (n-i), for additional sequences. Further tap points are given in Table 12 of the SX041, SX042, SX043 Users' Manual published by American Microsystems, Inc. of Idaho, USA which specific table is hereby incorporated by reference.

To avoid a dc component in the spread signal (which in the transmitted signal appears as a carrier spike) the codes are preferable "balanced", that is the number of 1's differs from the number of 0's by one. Balanced codes are obtained when an initial 1 of one of the m-sequences corresponds to an initial 0 in the other m-sequence.

The spread spectrum transmitter 206 preferably uses a relatively short spreading sequence, which simplifies the system design and provides higher baseband data rates. This permits the deactivation control signal to be shorter and thus allows faster tag deactivation. A short spreading sequence also reduced the spread spectrum processing gain, which is desirable since the tag range is preferably relatively short, or example, between 1m and 10m.

Gold codes may be used for distinguishing between signals simultaneously transmitted from multiple tags, as described in "Optimal binary sequences for spread spectrum multiplexing" by R. Gold, IEEE transactions on Information Theory, Vol.IT13, p.119-121, Oct. 1967, which is hereby incorporated by reference.

Gold codes are produced by modulo-2 addition of a "preferred pair" of two m-sequences generated by two shift registers with the same number, n, of stages. A Gold code has a length of 2^n - 1 and a single preferred pair can be used to generate a set or family of 2^n -1 different Gold code sequences (plus the two basis m-sequences). Each Gold code of a family is produced by combining the m-sequences with a different relative time shift; since there are 2^n -1 possible time shifts there are 2^n -1 different Gold codes in a set. The large number of different Gold codes available makes them useful in CDMA systems, although their autocorrelation functions are inferior to m-sequences. Gold code preferred pairs are listed in the paper by R. Gold mentioned above and in Tables 14 and 15 of the SX041, SX042, SX043 Users' Manual published by American Microsystems, Inc. of Idaho, USA. The specific Gold code preferred pairs listed are hereby incorporated by reference.

Figure 3 shows the receiver 200 of Figure 1b in more detail. Receiver 204 comprises a DSSS receiver of a conventional design. Such a receiver can, for example, be implemented cheaply using the SX042 and SX061 ICs available from American Microsystems, Inc. of Pocatello, Idaho, USA, in conjunction with a microcontroller (not shown in Figure 3).

The activation/deactivation detector 206 is coupled to a baseband output of receiver 204 and to a received signal strength indication (RSSI) output of the receiver. Detector 206 operates to provide an output to alarm device 302 when the RSSI falls below a threshold value without the deactivation signal having been received on the data input from receiver 204. The alarm device 302 preferably incorporates a button 304 to cancel the alarm, and drives a vibrator 306. In practice detector 206 and alarm 302 are preferably implemented on software running on a microcontroller which also controls the proprietary ICs of spread spectrum receiver 204 to write setup data into configuration registers, provide control functions, and receive data outputs from the spread spectrum decode ICs, and the like.

In some embodiments the alarm circuitry 302 may also be configured to send a signal to a mobile communications network, for example to send a signal to a pager or an SMS text message to a GSM mobile phone.

The invention has been described in the context of a DSSS transmitter but other spread spectrum transmissions may also be used, such as frequency hopping spread spectrum transmissions. The transmissions may be better concealed if they are arranged to look like or emulate Bluetooth (RTM) transmissions. In reduced costs systems AM transmissions modulated by short pulses can be employed (preferably at sufficiently low power to avoid the need for radiocommunications licensing).

No doubt many other alternatives will occur to the skilled person and it should be understood that the invention is not limited to the described embodiments.

CLAIMS:

1. A system for alerting a user having a tag receiver to separation from a tagged object, the system comprising a tag and a tag receiver, the tag comprising:

an activation/deactivation control device; and

a transmitter coupled to the control device;

the tag being configured to:

upon activation, start transmitting; and

upon deactivation, transmit a deactivation signal and cease transmitting;

the tag receiver comprising:

a receiver for receiving transmissions from the tag;

a detector, coupled to the receiver, for detecting a reduction in the strength of signal received from the tag and for detecting reception of the deactivation signal from the tag; and

an alarm device, coupled to the detector, for providing a user alert when a reduction in signal strength is detected without a deactivation signal.

2. A system as claimed in claim 1 wherein the deactivation signal comprises at least one pulse.

3. A system as claimed in claim 1 or 2 wherein the tag is a radio frequency tag providing an rf output modulated by a baseband signal comprising at least the deactivation signal, and wherein the half power bandwidth of the rf output is at least ten times the half power bandwidth of the baseband signal.

4. A system as claimed in claim 1 or 2 wherein the tag transmitter is a spread spectrum transmitter.

5. A system as claimed in claim 4 wherein the spread spectrum transmitter is a direct sequence spread spectrum transmitter.

6. A system as claimed in claim 4 wherein the spread spectrum transmitter is a frequency hopping spread spectrum transmitter.

7. A system as claimed in claim 6 wherein the frequency hopping spread spectrum transmitter operates substantially consistently with at least version 1.0 of the Bluetooth standard.

8. A system as claimed in any one of claims 1 to 3 wherein the transmitter, when activated, transmits an rf signal modulated by a tone.

9. A system as claimed in any preceding claim wherein the control device comprises an orientation-operated switch.

10. A tag for the system of any one of claims 1 to 9.

11. A tag receiver for the system of any one of claims 1 to 9.

12. A system, tag or tag receiver substantially as hereinbefore described.

ABSTRACT:

Tag and Receiver System

A system for alerting a user having a tag receiver to separation from a tagged object, the system comprising a tag (100) and a tag receiver (200), the tag comprising: an activation/deactivation control device (202); and a transmitter (206) coupled to the control device; the tag being configured to: upon activation, start transmitting; and upon deactivation, transmit a deactivation signal and cease transmitting; the tag receiver comprising: a receiver (204) for receiving transmissions from the tag; a detector (206), coupled to the receiver, for detecting a reduction in the strength of signal received from the tag and for detecting reception of the deactivation signal from the tag; and an alarm device (302, 306), coupled to the detector, for providing a user alert when a reduction in signal strength is detected without a deactivation signal. A corresponding tag and tag receiver.

The system helps prevent the loss of valuable objects.

Figure 2a.

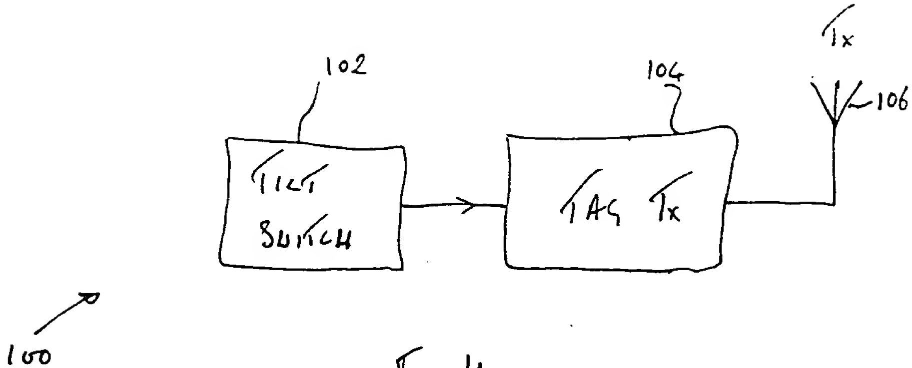

Fig 1A

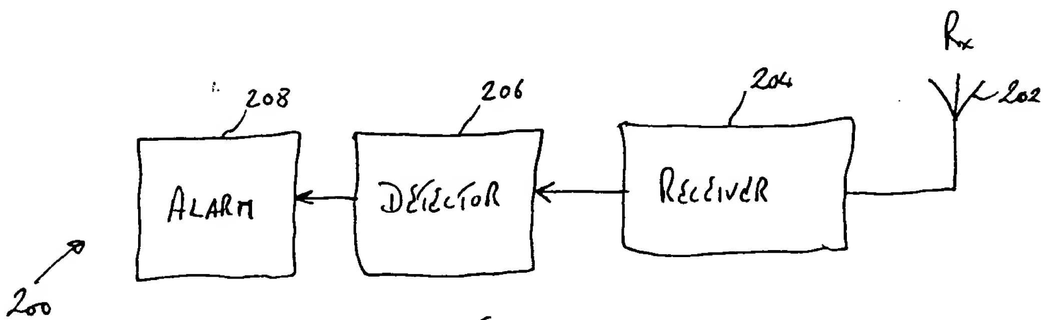

Fig 1B

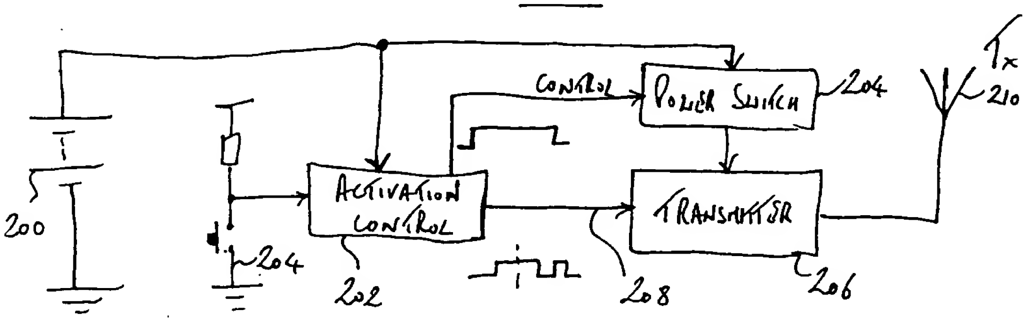

Fig 2A

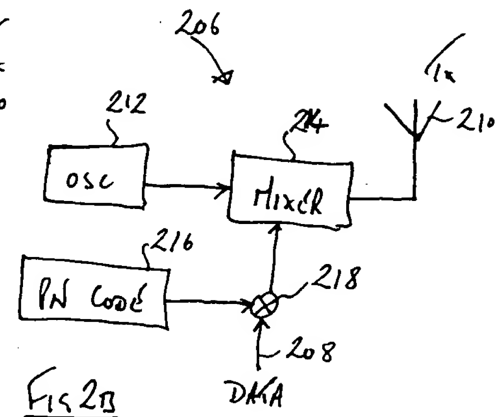

Fig 2B

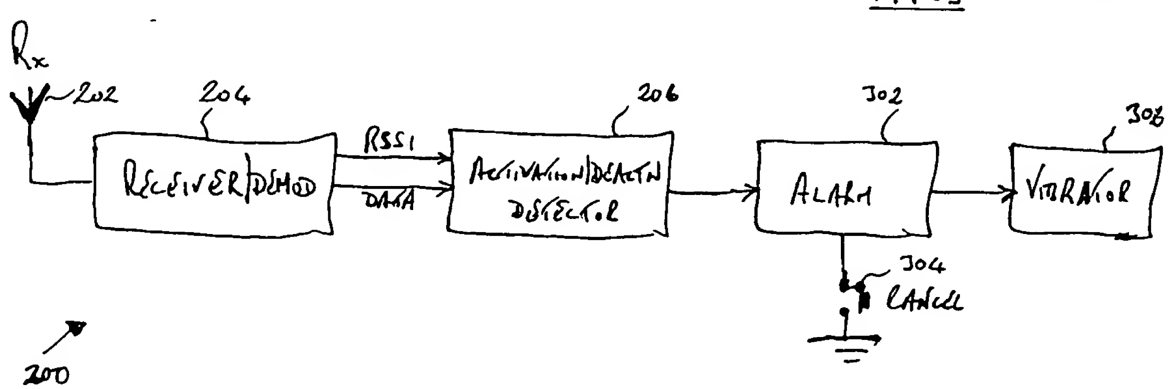

Fig 3